# DESIGN OF A SUSTAINABLE SMART MULTIPURPOSE HALL WITH GREEN ROOF FOR MINUYAN PROPER TOWERVILLE IN SAN JOSE DEL MONTE, BULACAN

An Experimental Research

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In Partial Fulfillment of the Requirement for the Degree

Bachelor of Science in Civil Engineering

Major in Construction Engineering

And Management

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## RECOMMENDATION

This is to certify that this research entitled "DESIGN OF A SMART MULTIPURPOSE HALL WITH GREEN ROOFS FOR MINUYAN PROPER, TOWERVILLE, SAN JOSE DEL MONTE, BULACAN," prepared and submitted by Joseph Fronda, Jhon Lawrence Neron, Zyrelle John M.Otayde, Nikka Parcon, have been examined and PASSED the PRE-ORAL DEFENSE.

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## ACKNOWLEDGEMENT

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Researchers hereby declare that the research is their own, and to they have a significant comprehension, effort, and perception. It contains no materials, previously published or written by another man or woman, substance, which has been widely used for the award of any degree or degree from a university or some other training institute in which appropriate acknowledgement is made within the research.

This research is produced by their work, other from the quantity that aid from others inside the assignment's design and conception, or in the style, presentation, and linguistics are discussed.

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## ABSTRACT

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# CHAPTER 1

## The Problem and Its Background

This chapter discusses the overview of the study including the introduction, background of the study, theoretical framework, statement of the problem, hypotheses, scope and limitations of the study, objective of the study, significance of the study, and definition of terms.

### Introduction

In the face of rapid urbanization, climate change, and resource depletion, Implementing creative design with sustainable development becomes a major part in modern urban planning. As cities evolve and adapt, there is a greater demand for environmentally friendly and technologically advanced infrastructure.

The proposed design attempts to develop a modern, flexible, and eco-friendly place for community events, gatherings, and occasions. This project seeks to build a landmark structure in the Minuyan Proper, Towerville that shows what may be accomplished with environmentally friendly architecture through the use of smart technologies and sustainable design concepts.

As naturally grown sponges, green roofs absorb rainfall and ease the strain on drainage systems. Although there are green roofs in the Philippines, primarily on corporate buildings in Metro Manila such as shopping centers and luxurious hotels, their uptake is constrained by high upfront costs, a lack of regulations, and a lack of government assistance and knowledge. Despite these hurdles, several organizations and developers are adopting green roofs because of their environmental benefits, which include better building insulation and a decrease in storm water runoff.

In addressing the community needs of a facility that can be used for multiple purposes such as gatherings, social events, sports events, emergency shelter. This study aims to enhance the quality of life for Minuyan Proper Towerville's residents by designing and developing a sustainable smart multipurpose hall with green roofs. It also seeks to improve the energy efficiency, air quality, urban biodiversity of the said community. By implementing innovative technologies and sustainable practices, this research will not only provide a flexible space but also for resilience.

**Background of the Study**

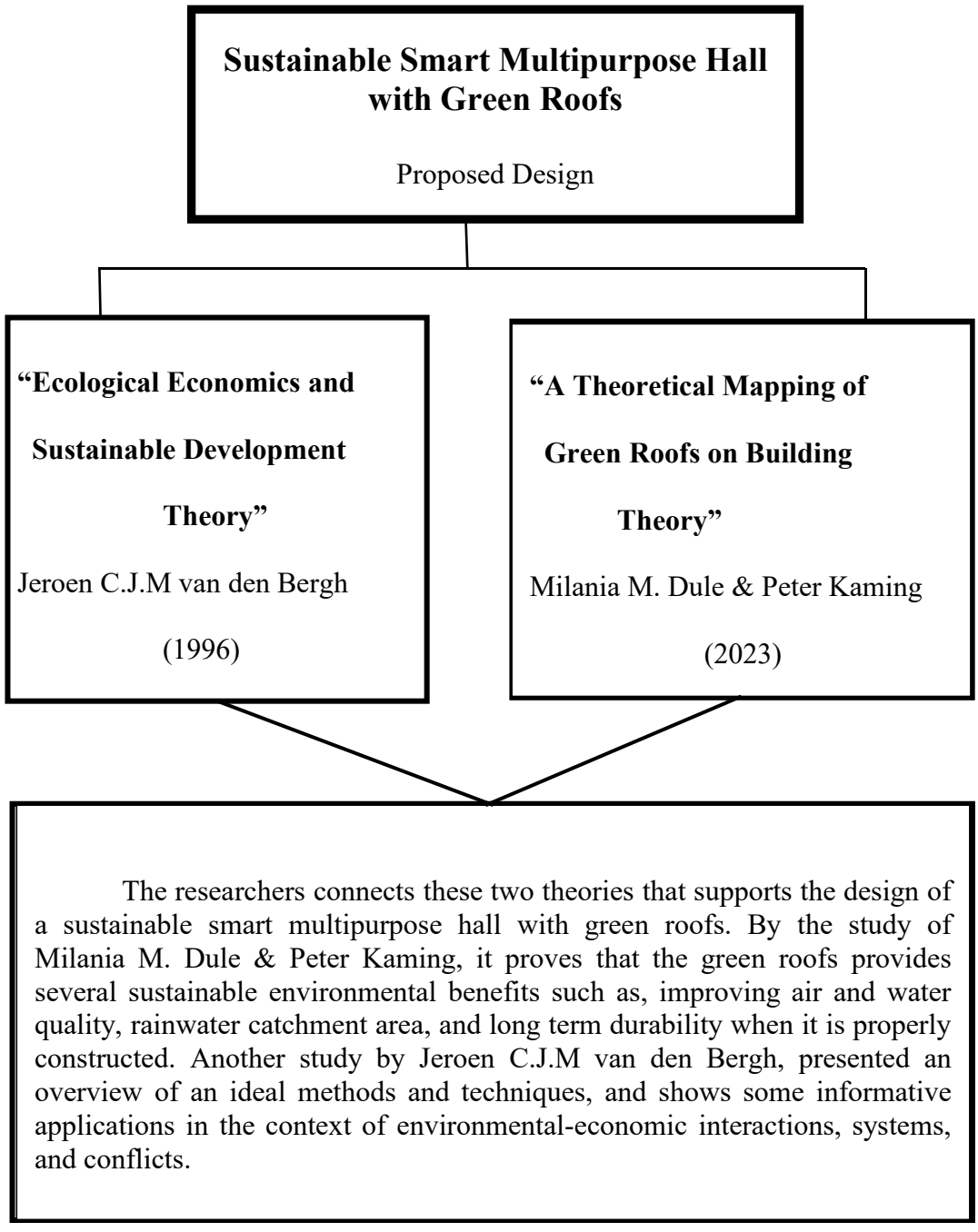
Minuyan Proper, Towerville, in San Jose Del Monte, Bulacan, is a developing community that lacks a varied and sustainable place for numerous events and activities. The current space for community's events and gathering is a basketball court, it faces limitations in terms of space and sustainability. These affects the community to hold activities that bring the residents together and help the community grow.

This study proposes the design of a sustainable Smart Multipurpose Hall with green roofs seeks to provide a modern, environmentally friendly, and technologically advanced place for community gatherings, events, and activities.

Past researches shows benefits and advantages of providing green roofs, as this study aims to provide a steps, a framework on how to build or to design a sustainable smart multipurpose hall with green roofs in Minuyan Proper Towerville in San Jose Del Monte, Bulacan.

In addition to enhancing storm water management, increasing urban biodiversity, reducing the urban heat effect, and minimizing energy costs through insolation, green roofs also improve air quality. Green roofs also reduces noise pollution, extend the lifespan of the roof structure underneath, and can produce aesthetically pleasing and useful green spaces for the people.

**Theoretical Framework**


Sustainable Smart Multipurpose Hall with Green Roofs
Proposed Design
"Ecological Economics and Sustainable Development Theory"
Jeroen C.J.M van den Bergh
(1996)
"A Theoretical Mapping of Green Roofs on Building Theory"
Milania M. Dule & Peter Kaming
(2023)
The researchers connects these two theories that supports the design of a sustainable smart multipurpose hall with green roofs. By the study of Milania M. Dule & Peter Kaming, it proves that the green roofs provides several sustainable environmental benefits such as, improving air and water quality, rainwater catchment area, and long term durability when it is properly constructed. Another study by Jeroen C.J.M van den Bergh, presented an overview of an ideal methods and techniques, and shows some informative applications in the context of environmental-economic interactions, systems, and conflicts.

**Conceptual Framework**

| INPUT | PROCESS | OUTPUT |
|---|---|---|
| 1. How the propose design can be functional in terms of:<br><br>1.1 Versatility<br>1.2 Adaptability<br><br>2. How can feature like green roof benefit the building and the community in terms of:<br><br>3.1 Saving energy<br>3.2 Managing rainwater<br>3.3Improving air quality<br>3.4 Adding beauty and comfort to the community<br><br>3. How will the design of smart multipurpose hall with green roofs contributes to the community development and improves the quality of life of the local residents in the community?<br><br>4. What will be the total expense of designing and developing of the smart multipurpose hall with green roofs? | - Conduct surveys<br><br>- Site Visiting<br><br>- Analyzing the collected data<br><br>- Designing of Model using Autocad<br><br>- Computation<br><br>- Application of design base on the resident's feedback. | |

**Statement of the Problem**

This study seeks to propose a new design of smart multipurpose hall with green roofs to provide highly innovative, eco-friendly space for community events in Minuyan Proper, Towerville in San Jose Del Monte, Bulacan. In addition, the researchers aim to answer the following questions:

1. How the propose design can be functional in terms of:
    1.1 Versatility
    1.2 Adaptability

2. How can feature like green roof benefit the building and the community in terms of:

    3.1 Saving energy
    3.2 Managing rainwater
    3.3 Improving air quality
    3.4 Adding beauty and comfort to the community

3. How will the design of smart multipurpose hall with green roofs contributes to the community development and improves the quality of life of the local residents in the community?

4. What will be the total expense of designing and developing of the smart mulipurpose hall with green roofs?

## Objectives of the Study

The primary objective of this study is to design a sustainable smart multipurpose hall with green roofs for Minuyan Proper Towerville in San Jose Del Monte, Bulacan. The researchers aim to achieve the following objectives:

1. To integrate energy-saving solutions and smart technologies that improve building efficiency and user experience.

2. To design a facility that is both flexible and adaptable to the community's various needs

3. To advance environmental sustainability, community engagement, and economic growth in Minuyan Proper.

## Hypothesis

**Ho.** The design of a smart multipurpose hall with green roofs does not have a significant effect on enhancing the quality of life of the residents, storm water management, urban bio diversity, and air quality in the Minuyan Proper Towerville, San Jose Del Monte, Bulacan.

**Ha.** The design of a smart multipurpose hall with green roofs does have a significant effect on enhancing the quality of life of the residents, storm water management, urban bio diversity, and air quality in the Minuyan Proper Towerville, San Jose Del Monte, Bulacan.

## Significance of the Study

**Local Residents**: by providing a much-needed flexible venue for numerous purposes like gatherings, social events, meetings, emergency shelter in the Minuyan Proper Towerville.

**Local Government Units:** by providing a design model for eco-friendly infrastructure that can improve the quality of life of not only the residents but also the community's biodiversity.

**Climate challenges**: by implementing green roofs that can enhance the community's environmental performance

**Future Researchers**: this project will help future student researchers as a reference in their future studies.

## Scope and Limitations

This study focuses on the design of a sustainable smart multipurpose hall with green roof that meets the needs of the residents in the Minuyan Proper, Towerville. The research will focus on sustainability, functionality, user experience, and community engagement. It also addresses project estimation cost and the environmental benefits in terms of air quality, storm water management, and urban biodiversity.

On the other hand, this study has some limitations, it only focuses on the design and it does not include the actual implementation and development of the

structure. The findings can also not be applied to other communities or cities as it focuses only on Minuyan Proper, Towerville in San Jose Del Monte Bulacan.

## Definition of Terms

**Adaptability**

the quality of being able to adjust to new condition.

**Green Roof**

a green roof is a vegetated roofing system which is functionally integrated onto a roof area.

**Multipurpose Hall**

a large, open space with a flexible design and adaptable features, built to accommodate a variety of events and activities

**Sustainability**

the practice of meeting present human needs without compromising the ability of future generations to meet their own needs, by balancing environmental, social, and economic concerns.

**Urbanization**

the process of cities growing larger as more people move from rural areas to live in towns and cities, leading to an increased proportion of the population living in urban centers.

**Versatility**

**-** ability to adapt or be adapted to many different functions or activities.

# CHAPTER 2

## Review of Related Literature and Studies

This chapter presents a review of related literature and studies, following a thorough search done by local and foreign researchers. Those included in this chapter aid in familiarizing with related information the the study.

### Foreign Literature

According to United States Environmental Protection Agency (2025), heat reduction was proven with the help of green roofs. Building green roofs, a vegetation layers grown in a rooftop, makes a lot of benefits such as its adaptability to remove heat from the air and reducing the temperatures if roof surfaces and surrounding air. As for the cities using green roofs or some environments with limited vegetation can be moderately reduce the heat island effect. Additionally, the surface temperature of green roofs can be lower than the conventional roofs. temperature reduction and energy efficiency benefits are a key contributor to the growing popularity of green roofs in the United States.

As stated by Yildirim, Ozburak, and Ozden (2023), increasing urbanization and climate change are the severe environmental issues that cities are facing where some effects of human stressors.

Climate change is worsening risks to the environment, particularly by increasing the frequency, duration, and intensity of weather extremes such as heat waves, floods, and droughts, all of which have an influence on biodiversity and ecosystem services.Stormwater drainage is often handled in many metropolitan areas by an impermeable infrastructure network, such as cast-iron catch pits, concrete lined gutters, pipe and manhole networks, and stream canalization. These networks inevitably enhance the volumes, flows, and flood peaks associated with stormwater runoff. Therefore, it is vital to find strategies that can reduce the hydrological hazard that urbanization poses.The excessive use of fossil fuels in recent decades has led to swift surface heating across the biosphere, which, alongside other human influences, is harming ecosystems and biodiversity. Energy conservation is one of the alternative approaches that humanity is currently exploring due to this problem. Alongside other energy-demanding industries and sectors like transportation, buildings consume approximately one-third of all energy and play a major role in CO2 emissions. For example, nearly 40% of the total energy consumed in the US in 2012 was derived from residential and commercial buildings. Recent approaches by city planner an some parts of the world are adopting for more efficient and sustainable infrastructure, wherein using green roof system for more sustainable development and long-term viability.

According to Clar and Steurer (2021), green roof are still considered rare even they are no-regret adaptation measures that helps various impacts on environment. Additionally, green roofs are considered an attractive solution for some

of environmental issues. However, even when the numerous benefits of green roofs are obvious, local governments prefer fiscal incentives to mandated legislation.

**Local Literature**

According Dela Cruz et al. (2021) emphasized that the integration of sustainable design strategies in public buildings, such as schools and barangay halls, plays a vital role in reducing energy consumption and improving environmental performance. Their research revealed that the use of passive cooling systems, natural lighting, and recycled materials can lower operational energy costs by up to thirty percent annually. They further noted that incorporating sustainable features like green roofs contributes to improved thermal insulation and stormwater management, making such designs ideal for multipurpose facilities in developing communities. These findings align with the principles behind a Smart Multipurpose Hall, which aims to combine functionality, sustainability, and energy efficiency within a single structure.

According, Castillo et al. (2022) conducted research on the environmental benefits of green roofs in Quezon City and discovered that these systems effectively lower rooftop surface temperatures, reduce carbon emissions, and absorb rainwater to prevent flooding. Their study also emphasized that green roofs improve air quality and biodiversity in urban environments. When integrated into a Smart Multipurpose Hall, these sustainable features can work in harmony with

smart technologies to regulate indoor climate, enhance energy conservation, and improve the overall environmental performance of the building.

According to Reyes et al. (2021) focused their research on the implementation of smart building technologies in local government facilities. Their study examined the use of intelligent systems such as motion-sensor lighting, automated ventilation, and digital energy monitoring. Results indicated that these technologies can cut power consumption by as much as 25–40% compared to traditional systems. Beyond energy efficiency, they also found that smart systems improve the safety and reliability of building operations. Applying these technologies to a Smart Multipurpose Hall would allow for real-time energy tracking and resource optimization, aligning the project with global sustainability standards.

Furthermore, According to Mendoza et al. (2024) analyzed the relationship between sustainable infrastructure and community development across several municipalities in Central Luzon. Their study concluded that green-designed facilities not only benefit the environment but also serve as hubs for social interaction and civic engagement. . The research emphasized that sustainable structures contribute to residents' quality of life by offering safe, comfortable, and environmentally responsible spaces for social gatherings and public functions.

Villanueva et al. (2023) investigated the practical challenges of implementing green and smart technologies in barangay-level infrastructure. Their study revealed that although initial construction costs can be high, the long-term benefits in energy

savings, reduced maintenance, and environmental resilience outweigh the expenses. They also underscored the importance of collaboration between local government units, engineers, and residents to ensure project success. By integrating green roofs, smart systems, and sustainable design elements, public facilities can become models of modern, eco-friendly development that benefit both the environment and the community.

**Foreign Studies**

According to Li et al. (2020), a study an focusing smart buildings and homes were identified in advancement in energy-related smart building technologies, including energy management systems, renewable energy applications, and advanced smart technologies. It also highlighted the solutions with energy management systems and practical designs, inclining for the human activities and technology advancement. It aims in understanding the pathway toward future smart homes and buildings and their technologies. A major contributor to the world's energy consumption and greenhouse gas emissions is the building industry. Energy sustainability in the built environment has been enhanced by developments in building energy technologies. Numerous applications for smart homes and buildings have been created to improve people's everyday lives and the sustainability of the built environment. For future structures and community levels, it is essential to comprehend how energy moves between buildings and their ecologically interconnected systems.

As stated by Li and Yeyng, green roofs can be traced back as far as the gardens of Babylon and the Roman Empire, i.e. they grew trees on top of buildings. Major American cities' rooftops were greened in the 19th and 20th centuries to make up the growing land expenses associated with creating inner-city parks. Germany is currently the world leader in green roof technologies, with over 10% of homes having green roofs. The country's first wave of green roof construction began at the end of the 19th century. During this boom, less than 1% of German roofs were covered by it. These days, green roofs are also common in other European nations, such as France and Switzerland. Additionally, green roofs play a critical role in improving the urban environment by enriching the biodiversity, delaying the storm peak to the drainage system, diminishing the runoff quantity, purifying the air pollutants as well as the runoff quality.

According to Tseng et al. (2022), Due to extensive urban planning and urban commercial growth, green covering has gradually decreased, creating wall effects and urban heat island effects1. Globally, increasing the area of greenery in cities and successfully tackling environmental deterioration have emerged as priorities for urban improvement. In order to mitigate the effects of global warming, this study proposes that green roofs be built as urban oases. Depending on the types of plants that are potted on them and the soil's thickness, green roofs can be divided into three categories: potted, thin, and thick. To choose the best design, the many needs and conditions of the green roofs are evaluated.

According to Li et al. (2020), a study a focusing smart buildings and homes were identified in advancement in energy-related smart building technologies, including energy management systems, renewable energy applications, and advanced smart technologies. It also highlighted the solutions with energy management systems and practical designs, inclining for the human activities and technology advancement. It aims in understanding the pathway toward future smart homes and buildings and their technologies. A major contributor to the world's energy consumption and greenhouse gas emissions is the building industry. Energy sustainability in the built environment has been enhanced by developments in building energy technologies. Numerous applications for smart homes and buildings have been created to improve people's everyday lives and the sustainability of the built environment. For future structures and community levels, it is essential to comprehend how energy moves between buildings and their ecologically interconnected systems. Sustainable Community

As stated by Roseland et al.(2018), sustainable development and sustainable communities, highlighting the need for conceptual clarity in selecting high-quality indicators to monitor progress. In sustainable communities it empathizes in social and environmental needs. In this way frameworks, policymakers, and practitioners are working together on creating more sustainable communities to meet the need of humans while having the capacity of creating environmental sustainability.

Xuekelaiti Haiyirete, Wenjuan Zhang and Yu Gao (2024), smart building technology is subtly changing the rules of the standard construction game in an industry that has not yet fully embraced digitalization, making us reevaluate what "building" means. The profound integration of architecture and digitalization has increasingly made smart construction technology a basic feature of the construction sector. Past researches says that 21st century was the most favorable stage for digitalization and smart construction technology. Jn 2022, at European Commission work called Horizon Europe, it emphasized that digital transformation is the key for achieving the green transformation. It also stated in various articles and studies of other countries also introduced a series of policies to promote smart construction technology.

University of Built Environment (2025), smart buildings can be represented by the intelligent, connected and sustainable future of the built environment. Which also mean built environment is digital transformation. Just like as technology keeps on evolving and revolutionizing among industries like IT, finance, healthcare and manufacturing, it’s also transforming the way structures are designed, built and operated. The term smart buildings have become common in sectors in recent years. But rather than just being another technological buzzword, this new wave of digital transformation has enormous implications for both the built environment and for sustainability Smart buildings are structures that utilise technology to optimise resource usage, efficiency and comfort for occupants.

**Local Studies**

Alonzo et al. (2021) conducted a study on the Implementation of Energy-Efficient Systems in Barangay Halls within Metro Manila, which evaluated the impact of smart technologies such as motion-sensor lighting, solar-powered ventilation, and energy-monitoring systems on the overall energy consumption of local government facilities. Their findings revealed that the application of smart systems in small-scale infrastructures can reduce electricity consumption by up to thirty-five percent, proving that these technologies are both practical and effective for improving operational efficiency in community buildings. Likewise

According De Vera et al. (2022) assessed the feasibility of green roofs in local government infrastructures in Bulacan and discovered that vegetated roofing systems not only improve building insulation and extend roof durability but also help manage stormwater runoff and mitigate the urban heat island effect. Their research concluded that integrating green roofs in municipal structures provides both environmental and economic benefits, making them suitable for public facilities such as multipurpose halls.

The study of Ramos et al. (2023) examined Smart Infrastructure Design for Sustainable Community Development in Central Luzon, focusing on the integration of Internet of Things (IoT) sensors, automated systems, and digital energy management in public facilities like health centers and multipurpose halls. The study found that the use of smart monitoring systems improved energy efficiency,

enhanced building safety, and allowed for data-driven decision-making in infrastructure maintenance. Ramos et al. also emphasized that the incorporation of smart technologies promotes sustainability by ensuring that energy and water resources are used more responsibly.

Furthermore Manalo et al. (2023) explored Community-Based Green Architecture in Urban Barangays of Quezon City and discussed how the application of sustainable design features, such as solar panels, rainwater harvesting systems, and rooftop vegetation, enhances urban livability and environmental quality. Their study demonstrated that eco-friendly infrastructure not only contributes to energy conservation but also fosters community awareness and participation in environmental protection initiatives.

According  Villareal et al. (2024) conducted a comprehensive study on the Design and Cost Analysis of Sustainable Multipurpose Halls in Bulacan Municipalities. Their research evaluated both the technical and economic viability of incorporating green technologies, including solar power systems, vegetated roofs, and natural ventilation designs in public structures. Although they found that sustainable materials and smart systems may increase the initial construction cost, the study concluded that long-term benefits—such as reduced maintenance expenses, lower electricity usage, and improved environmental resilience—make the investment highly cost-effective. Moreover, the study emphasized that sustainable

multipurpose halls play an important role in community building, as they provide inclusive spaces for social gatherings, disaster response, and civic engagement.

**Synthesis of Review of Related Literature**

The related literature and studies above reveals that the use of green roofs and smart building bring a lot of benefits to the both community and the environment.

Castillo et al. (2022).Their study also emphasized that green roofs improve air quality and biodiversity in urban environments. Dela Cruz et al. (2021), Their research showed that by using natural cooling and recycled materials it can lower the energy costs up to 30%. Manalo et al. (2023), This research emphasized that green building helps reduce energy use and it also helps people to be aware and protect the environment. Villanueva et al. (2023), Their study showed that the cost of construction for smart building is higher, the environmental impacts and energy saving makes it worth it. University of Built Environment (2025), smart buildings prioritize improving occupant experience, operational effectiveness, and building performance

# CHAPTER 3

## Research Methodology

This chapter presents the research methodology and procedures used by the researchers to conduct the study. It discusses the research design, data collections method, tools and materials used throughout the progress, and statistical procedures to ensure the study is accurate.

### Research Design

This study will use Quantitative Descriptive research design to gather data on the current issues of Minuyan Proper, Towerville. The researchers will gather information about the community's needs and environmental problem through surveys and site investigation. The gathered data will serve as a guide for designing a sustainable smart multipurpose hall.

### Sample and Population

The target population for this study includes the local residents from Minuyan Proper, Towerville, San Jose Del Monte, Bulacan. These people are chosen as respondents as they are directly affected and will benefit from the proposed design of the smart multipurpose hall. A sample of 100 local residents is selected for the study.

**Sampling Technique**

The researchers will use a simple random sampling method in selecting the respondents. Through this method, any local resident from Minuyan Proper, Towerville has the opportunity of being selected to participate in the survey.

**Data Analysis and Data Gathering Instrument**

For this study, the researchers primary data collection methods includes surveys, one on one interview, site investigation, map and AutoCAD. These are the tools that will provide the data required for designing a sustainable smart multipurpose hall.

**A. Survey Questions/Interview**

A survey questionnaire with 10 simple questions is used to gather information from the local residents of Minuyan Proper, Towerville. It assessed needs community situation, the benefits of green roof, and the acceptance of the community's resident to the multipurpose hall. The questionnaire is given to random 100 residents from the community.

**B. Site Investigation**

The researchers will visit and observe the site location to gather important data. This will help the researchers to understand the best design approach that fits the location and environment.

### C. AUTOCAD

The researchers will used AutoCAD as main instrument for detailing and designing of the sustainable smart multipurpose hall. It will help the researchers to create layouts and design, based on the collected information from surveys and site investigation.

### D. Map

The researchers used google earth to identify the exact location of the proposed design. It will help the researchers to see how accessible and what are the important landmarks in the area.

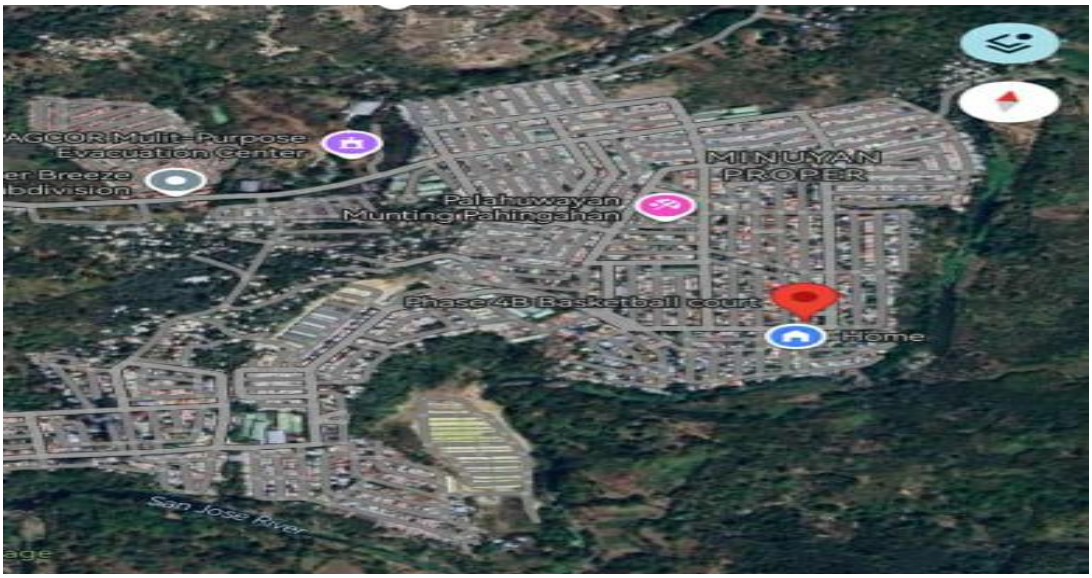



Figure 1. Map of Minuyan Proper, Towerville, San Jose Del Monte Bulacan